U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 87.

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end of file.

Experiment Station Work,

VIII.

SOIL MOISTURE.
FERTILITY OF SOILS.
COVER CROPS FOR ORCHARDS.
CULTIVATING v. CROPPING ORCHARDS.
TRANSPLANTING TREES.
FECUNDITY OF SWINE.
FOOD VALUE OF EGGS.
STARCH FROM SWEET POTATOES.
THE TOAD AS A FRIEND OF THE FARMER.

PREPARED IN THE OFFICE OF EXPERIMENT STATIONS.

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CONTENTS OF THE SERIES OF FARMERS' BULLETINS ON EXPERIMENT STATION WORK.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
OFFICE OF EXPERIMENT STATIONS,
Washington, D. C., December 15, 1898.

SIR: The eighth number of Experiment Station Work, prepared under my direction, is transmitted herewith with the recommendation that it be published as a Farmers' Bulletin.

Respectfully,

A. C. TRUE,
Director.

Hon. JAMES WILSON,
Secretary of Agriculture.

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ILLUSTRATIONS.

EXPERIMENT STATION WORK—VIII.[1]

CONSERVING AND ECONOMIZING THE MOISTURE OF THE SOIL.

Next to temperature, moisture is probably the controlling factor in the growth of plants. The importance of an adequate supply of moisture is most strikingly demonstrated in regions of deficient rainfall where irrigation is necessary for the growth of crops (arid regions), but it is no less important in regions where the rainfall is usually considered sufficient for the needs of crops (humid regions). Not only must there be a sufficient supply of moisture, but it must be properly distributed throughout the growing season. It is well known that crops may be injured by drought in a season which shows a high total rainfall, because there is a deficiency of rain just at the stage when the plant needs it most.

Under all circumstances, therefore, it should be the farmer's aim to conserve the moisture in the soil—in the arid regions to reduce as much as possible the labor and expense of irrigation, and in humid regions to protect crops against droughts. Various means may be employed for the purpose of conserving and economizing the moisture supply of soils.

Subsoiling is one of the most important of these means. Several of the stations have made careful studies of the influence of subsoiling on soil moisture.[2] The Wisconsin Station describes this influence substantially as follows: Subsoiling (1) increases the storage capacity of the soil for moisture, and (2) increases the rate at which water will sink into the soil, but (3) decreases the rate at which it may be brought

[1] This is the eighth number of a subseries of brief popular bulletins compiled from the published reports of the agricultural experiment stations and kindred institutions in this and other countries. The chief object of these publications is to disseminate throughout the country information regarding experiments at the different experiment stations, and thus to acquaint our farmers in a general way with the progress of agricultural investigation on its practical side. The results herein reported should for the most part be regarded as tentative and suggestive rather than conclusive. Further experiments may modify them, and experience alone can show how far they will be useful in actual practice. The work of the stations must not be depended upon to produce "rules for farming." How to apply the results of experiments to his own conditions will ever remain the problem of the individual farmer.—A. C. TRUE, Director, Office of Experiment Stations.

[2] See also U. S. Dept. Agr., Farmers' Bul. 56 (Expt. Sta. Work—I, p. 20).

back to the surface. Subsoiling also increases the amount of moisture available to crops, since plants are capable of utilizing a larger proportion of the moisture present in loose and coarse-grained soils than of that in fine-grained and compact soils.

As regards the best method of subsoiling, a report of the Wisconsin Station states:

> Subsoiling to be most effective should be done in such a way as to leave the soil loose, much as the stubble plow leaves it. To accomplish this much will depend upon the character of the tool and more upon the condition of the soil when the work is done. If the soil is so wet as to be plastic when the plowing is done, then the effect of the subsoil plow will be to wedge the portions of the soil, which are heavily pressed into an even more compact and close texture than before, and thus develop a condition the opposite of that sought. To simply form a long groove or channel in the subsoil by wedging the dirt aside gives little aid in the direction sought.
>
> Such work, then, if done at all, should be done when the subsoil itself is dry enough, and this is most likely to occur in the fall after the crop of the season has withdrawn the moisture from it. Subsoiling late, too, leaves no time for the soil to lose its open texture before the rains to be stored reach it.

In humid regions, as a recent bulletin of the California Station points out, the soil as a rule is underlaid at a comparatively short distance below the surface by a subsoil which the roots of plants penetrate with difficulty and from which they can draw little nourishment. The roots, therefore, spread out near the surface, and the plants require frequent rains or irrigation to sustain life. A suspension of either rain or irrigation for ten days or two weeks under these conditions usually results in injury to the plant. Under such circumstances subsoiling encourages deep rooting, and thus enlarges the stock of water as well as plant food at the command of the plant. In many parts of the region of deficient rainfall, as in southern California, plants (especially fruit trees) are capable of withstanding months of drought. This is claimed to be due to the fact that "in the arid region, as a rule, subsoils in the eastern sense do not exist; the soil is readily penetrable to great depths." This difference in the root systems of plants in humid and arid regions is illustrated in the accompanying figures.

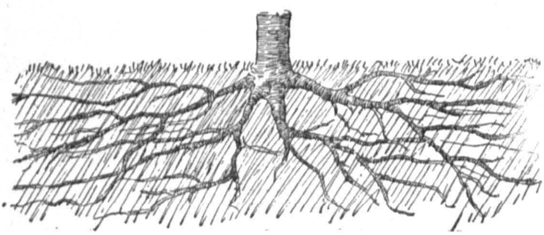

FIG. 1.—Root system of a tree growing on a soil with hard subsoil.

> A glance at the figures suffices to show that while a root system like fig. 1 will stand in absolute need of frequent rains or irrigation to sustain its vitality, such a one as fig. 2 may brave prolonged drought with impunity, being independent of surface conditions, and able to perform all its functions out of reach of stress from lack of moisture. It is equally clear that it is to the farmer's interest to favor to the utmost this deep penetration of the roots.

This can be done in humid regions, to some extent at least, by thorough preparation and tillage of the soil and (in case of fruit trees) by guarding against excessive surface fertilization. In arid regions frequent irrigation, it is claimed, encourages shallow rooting.

To prevent loss of water from the soil by evaporation it is necessary to check the rise of water by capillarity to the surface of the soil. As already noted, this is accomplished to some extent by subsoiling, but in order that the work partly accomplished by the subsoiling may be completed and continued, the surface of the soil must be kept covered with a mulch of loose, well-tilled soil by means of frequent tillage. Some experiments of the Kansas Station afford an illustration of the effectiveness of this means of conserving soil moisture.

One of the station fields which contained in round numbers 26 per cent of water in the first foot of soil, on July 7, 1898, had one portion plowed, another disk harrowed and a portion left untreated. The ensuing dry weather in the course of four weeks, notwithstanding several light rains, reduced the moisture of the untreated part to 15 per cent and that of the disked land to 18 per cent, the plowed ground retaining 21 per cent. The last two were in excellent condition for seeding, while the first would plow up lumpy and unsatisfactory.

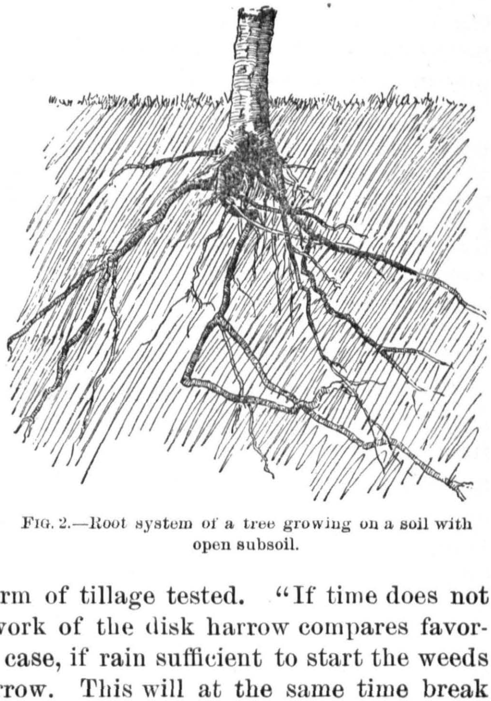

FIG. 2.—Root system of a tree growing on a soil with open subsoil.

In the experiments at the Kansas Station plowing proved as effective as any form of tillage tested. "If time does not permit plowing, the speedy work of the disk harrow compares favorably in efficiency. In either case, if rain sufficient to start the weeds follows, kill them with a harrow. This will at the same time break up any crust and preserve the soil mulch."

Whether the best results in preventing loss of moisture from the soil in humid regions will be obtained by subsoiling, shallow cultivation, or deep cultivation will depend very largely upon the character of the soil and subsoil. The Kansas Station found no essential difference in the moisture content at the different depths of soil that had been prepared in the spring by shallow plowing, by deep plowing, and by subsoiling. In experiments at the North Dakota Station on different methods of preparing soil and tillage for wheat the largest yield was obtained from land subsoiled 8 inches below a 6-inch furrow. A surface mulch of well-tilled soil 3 or 4 inches thick is usually considered

sufficient to afford effective protection against evaporation in humid regions. In regions of deficient rainfall, however, twice this depth is considered necessary.

In humid regions there is danger of serious loss of nitrates in subjecting bare plowed land to the long-continued leaching action of abundant rains, as is done in summer fallowing and fall plowing; nevertheless, the Kansas Station has found that the plowing of stubble as soon as possible after the removal of the previous crop, with frequent stirring of the soil, as described above, "not only insures a perfect seed bed for wheat in respect to moisture, but the soil has time to settle to the firm condition so advantageous to wheat, and the bareness, warmth, and moisture are most favorable to the formation of nitrates from organic matter." In regions of deficient rainfall loss by leaching need not be feared. Under such conditions both summer fallowing and fall plowing may prove of great value in conserving moisture.

Fall plowing wherever the land is not naturally adequately absorbent, and is not thereby rendered liable to washing away, is a very effectual mode of utilizing the winter's moisture to the utmost, so as to bring about the junction of the season's moisture with that of the previous season, which is generally considered as being a condition precedent for crop production in dry years. The same of course holds true of winter irrigation, the frequent omission of which in presence of a plentiful water supply at that season is a prolific cause of avoidable crop failures. Moistening the ground to a considerable depth by winter irrigation is a very effective mode of promoting deep rooting, and will thus stand in lieu of later irrigations, which, being more scant, tend to keep the roots near the surface.

Moisture escapes from soils bearing crops much more rapidly than from bare soils. This fact has been very clearly demonstrated by investigations by the Iowa, Kansas, Wisconsin, and other stations. These investigations show that sod land and soil bearing different crops always maintain less moisture than uncultivated soil of the same character. It is undoubtedly true that the injurious effect of weeds is due fully as much to the moisture which they withdraw from the soil as to the plant food which they consume. The poor growth of crops near hedgerows and woods is due largely to withdrawal from the soil of moisture required for the proper growth of the crops. It is a well-known fact that the culture of crops in orchards may prove injurious to fruit trees, especially in dry seasons. (See p. 18.) This is due mainly to the withdrawal by the crops of moisture needed by the trees. The danger from this source is especially great if the fruit trees are very shallow rooted. From the standpoint simply of conservation of moisture, therefore, the farmer should be careful to keep his land free from unnecessary vegetation during the summer, "but it must not be forgotten that by doing so he quickly depletes his land of vegetable matter, which requires systematic replacement if production is to continue normally," and, as explained above, he incurs danger of serious loss of nitrates by leaching and washing, especially in season of heavy rainfall.

It is thus seen that while there are many ways in which the moisture

of the soil may be wasted or rendered useless to the plant, there are also many effective means of conserving and economizing this water which may be profitably employed. It only remains for the individual farmer to determine the method best suited to his needs and conditions.

INFLUENCE OF DIFFERENT SYSTEMS OF FARMING ON THE FERTILITY OF THE SOIL.

The amount of principal elements of fertility removed from the soil in products sold from the farm and the amount returned to it in the form of manure depend largely upon the system of farming practiced. It is well known that soils under continuous cultivation decline in fertility much more rapidly than those kept in grass. This is due not only to the constant removal of fertility in the crops harvested and sold from the farm, but also to the fact that under most systems of continuous culture the soil is left bare a large part of the time, and thus subjected to loss from leaching, washing, and oxidation. On the other hand, soils in grass are protected almost entirely from the latter losses. The roots of the plants bring up the fertilizing constituents from the lower layers of the soil and they accumulate at the surface of the soil in the decaying remains of the vegetation. Thus in case of grass lands, while there is no actual gain in total amount of fertilizing constituents in the soil, the plant food is made more available and accessible. These facts explain the apparent recuperation of soils which have been exhausted by continuous culture when kept under grass for a number of years. If leguminous plants are substituted for grasses, there may be an actual gain in fertility due to the nitrogen which these plants are capable of collecting from the air.

When the lands are grazed by sheep and cattle the soil fertility is drawn upon to the extent of the nitrogen, phosphoric acid, and potash required to build the blood, bone, and tissue of the animal body. This is considerable in the case of growing animals, but insignificant in case of animals which have made their growth (especially of bone) and are simply maintained or fattened on the pasture. If, however, concentrated feeds are used in addition to pasture, and the manure produced returned to the land, there is an actual gain in fertility of the land. It will thus be seen that exclusive grain farming or continuous culture of a single crop has a much greater tendency to impoverish the soil than stock raising or combined grain and stock raising. A comparison of the amount of plant food removed from the soil and the amount capable of being returned to it under different systems of husbandry has been made by the Minnesota Experiment Station. The systems taken into consideration were all-grain farming, mixed grain and general farming, mixed potato and general farming, stock farming, and dairy farming, examples being selected which represented the different systems. In each case the farm is considered to contain 160 acres.

In the example of all-grain farming selected no stock was kept and

no fertilizers of any kind applied to the land, the small amount of fertilizing material which necessarily accumulated was disregarded, and the grain was all sold from the farm. The entire farm of 160 acres was under cultivation. The crops raised were 100 acres of wheat, 40 acres of barley, and 20 acres of oats, yielding 15, 40, and 50 bushels per acre, respectively. It is calculated that the fertility removed from such a farm in the grain and straw of one year's crops amounted to 2,460 pounds phosphoric acid, 4,020 pounds potash, and 5,600 pounds nitrogen. This does not include the fertility removed by the weeds, which often is very large, and the amount of nitrogen lost from the soil through leaching and the decomposition of humus.

The amount of nitrogen thus lost from a rich prairie soil recently brought under this system of farming is three or four times that removed in the crop. It was found from experiments conducted at this station that when a prairie soil is first brought under cultivation the humus oxidizes rapidly, but as the soil grows older the humus content diminishes and the oxidation of the humus goes on more slowly.

The system of mixed grain and general farming studied consisted of growing 40 acres of wheat, 20 of oats, 10 of barley, 7 of rye, 5 of corn, 3 of flax, and 1 each of peas, millet, and potatoes. The rest of the land was in meadow and pasture, and 10 cows, 4 head of young stock, 15 sheep, 8 hogs, 4 work horses, and 2 steers were kept. All the straw produced was used as feed and bedding for the stock. The yields in this case were higher than under all-grain farming, because the land was kept in better condition. All the wheat, rye, and flax, and one-half of the oats and barley, and 50 bushels of potatoes were sold from the farm. The animal products sold were 2 steers, 10 sheep, 8 hogs, and 1,500 pounds of butter. The remaining oats, barley, and potatoes, and the corn, peas, and millet, besides 20 tons each of timothy and clover, were consumed on the farm, and 80 per cent of these food materials were returned to the soil in the form of manure. The fertility returned to the farm in manure from the food purchased, such as bran, screenings, and meal of various kinds, was taken into consideration in every case. A comparison of the total amount of fertility removed from the farm and the amount returned to it shows an approximate loss from the soil of 1,003 pounds phosphoric acid, 1,047 pounds potash, and 2,594 pounds nitrogen. The fixation of the free nitrogen of the air by clover and peas was not taken into accouut in these figures, but "it is safe to calculate that there has been a gain of 1,500 pounds of nitrogen from this source." When allowance was made for the nitrogen thus obtained there was an annual loss from this farm of about 1,000 pounds each of phosphoric acid, potash, and nitrogen. There was therefore a loss of about two-fifths as much phosphoric acid, one-fourth as much potash, and one-sixth as much nitrogen as in all-grain farming. With good cultivation and management it is believed that the reserve fertility of a good soil will withstand the above losses for a number of years.

The system of mixed potato and general farming studied differed from the foregoing system in that about 40 acres of grain were replaced by potatoes and that less grain was sold and less mill products purchased. The stock kept consisted of 7 cows, 4 head of young stock, 4 horses, 2 steers, 12 sheep, and 9 hogs. Besides, 40 acres of grain were grown, of which 15 were sold. The rest of the farm was mainly in meadow and pasture. The products sold from the farm were 6,000 bushels of potatoes, 1,000 pounds of butter, 8 hogs, 2 steers and young stock, 10 sheep, and the yields of 10 acres of oats and 5 of barley. Fifteen tons each of clover and timothy, 40 tons of straw, 150 bushels of potatoes, and the yields of 10 acres each of oats and barley, 5 acres of corn, and 1 acre each of millet and peas grown on the soil were consumed on the farm. Here, as in the previous example, 80 per cent of the food consumed was returned to the soil. The approximate loss from the soil under the system amounted to 991 pounds of phosphoric acid, 2,435 pounds of potash, and 2,463 pounds of nitrogen. Deducting the nitrogen accumulated in the soil through the agency of the clover crop, the net loss of nitrogen is less than 1,000 pounds. Another advantage of growing clover, as pointed out, is that a deep-feeding crop, like clover, will bring up the fertility from the lower layers of the soil and concentrate it in the surface soil. This is especially desirable in potato farming which makes a heavy draft on the fertility of the soil, especially the potash.

In the example of stock farming selected for study, 25 acres were sown to oats, 20 to barley, 10 to corn, 5 to peas, and 1 acre each to potatoes and millet. The remainder of the farm was in meadow and pasture. The stock kept in this case comprised 10 beef cattle, and 10 dairy cows, 10 horses, 5 steers, 10 head of young stock, 30 sheep, and 20 hogs. Five steers of 1,000 pounds each, 5 head of young stock, 5 horses, 10 hogs of 250 pounds each, and 1,500 pounds of butter were sold from the farm. All the crops grown, including 40 tons of timothy and 30 tons of clover, were consumed on the farm. Eighteen tons of food material and 5 cords of wood were purchased and consumed, besides the crops produced. Under these conditions there was approximately a gain of 35 pounds of phosphoric acid, and a loss of 50 pounds of potash, and 898 pounds of nitrogen. The loss of nitrogen was more than balanced by the gain due to the clover crop, so that on the whole there was practically no loss of fertility from the farm.

In the example given of a dairy farm, 30 cows, 5 head of young stock, 4 horses, and 20 pigs constituted the stock kept on the farm. The crops raised were 10 acres of wheat, 20 of oats, 10 of corn, 7 of rye, 5 of oats for hay, 2 acres each of roots and peas, 1 each of millet and potatoes; 25 tons of both clover and timothy were produced, and the remainder of the farm was mainly in pasture. Sixteen pigs of 250 pounds each and 4 head of young stock, 5,000 pounds of butter, and all the wheat and rye produced were sold from the farm, while the rest of the products were consumed as feed and 80 per cent returned to the

soil as fertilizer. Ten tons of feed and 5 cords of wood were purchased and consumed in addition to what was produced on the farm. The figures given for dairy farming show a gain of 76 pounds of phosphoric acid and a loss of 85 pounds potash, and 809 pounds nitrogen. The loss of nitrogen, however, is again more than offset by the gain through the clover crop, so that there is practically no loss of fertility in dairy farming under proper management, but rather a constant gain.

The loss of fertility under the different systems of farming is given in the following table. The gain of nitrogen through clover culture is disregarded in these figures:

Approximate loss of fertility from 160 acres of land under different systems of farming.

System of farming.	Phosphoric acid.	Potash.	Nitrogen.	Mineral matter.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*
All grain	2,460	4,020	5,600	18,420
Mixed grain and general	1,003	1,047	2,594	5,419
Mixed potato and general	991	2,435	2,363	6,070
Stock	*a* 35	59	898	3,243
Dairy	*a* 76	85	809	1,818

a Gain.

These figures given * * * are not intended to convey the idea that an equivalent amount of each element must always be returned to the soil, but they are intended to show where the heaviest drafts fall on the soil with each system of farming.

In making comparisons, the variations which are liable to occur should be kept in mind. In exclusive grain farming the loss of the nitrogen is greater than given because when the soil is continually uncovered by the cultivation of plowed crops some of the nitrogen is lost by drainage and by the decomposition of the humus. When clover is grown in the other systems of farming, the loss of the nitrogen is less than stated.

The annual loss of phosphoric acid with exclusive grain farming is nearly 2,500 pounds per 160 acres. With mixed grain or potato farming this loss is reduced to about 1,000 pounds.

With stock farming, when all of the crops are fed to the stock on the farm and a small amount of milled products is purchased, there is practically no loss of phosphoric acid and potash, except in the handling of the manure. When the manure is well cared for, the losses of these elements are both less than stated.

In the case of dairy farming or stock farming, when all of the skim milk is fed on the farm and a part of the grain is exchanged for more concentrated milled products, there is no loss, but on the other hand a constant gain of fertility to the soil.

COVER CROPS FOR ORCHARDS

An orchard cover crop is a crop grown in the fall and winter to protect the soil and trees of orchards, and at the same time to improve the soil. Unlike crops grown throughout the season, cover crops, as a rule, do not injure the trees by drying out the soil, for in many places heavy fall rains are the rule, and even where the weather during the fall is normally dry the injury is less than in summer, since plants evaporate less water from their leaves in the cooler weather and shorter days of fall than in the longer and hotter days of summer. Cover crops not only

do not, as a rule, dry out the soil injuriously, but they also add directly to the moisture-holding capacity of the soil by the humus formed in their decay, and they hold much of the snow until it melts and is absorbed by the soil.

Another reason why cover crops are rarely as injurious as crops grown throughout the entire season and are often beneficial is that their growth is made after the trees have stopped growing and are maturing their wood for winter. The Michigan Station has shown that the majority of trees in that locality complete their growth by July. Of course, the conditions observed in Michigan do not occur in all climates or seasons, but they show unmistakably the tendency of trees to make their greatest growth early in the season. Trees therefore require much less moisture in the latter part of the season than they do in the early part. Indeed, in moist localities it is often thought to be a distinct advantage to stop cultivation by midsummer and grow some secondary crop which will check the growth of the trees and cause them to mature before winter. The Washington Station, in studying the unusually severe freeze occurring in the fall of 1896, found that in most instances late summer cultivation had an injurious effect similar to late irrigation. "Wherever cultivation or irrigation had been kept up late in the season and the ground was moist and the trees in an active growing condition, there the frost did most damage."

Among other benefits to be derived from cover crops is the checking of washing and leaching of the soil. Light soils are often gullied by heavy rains in the fall just as in summer, and some crop to bind such soils is beneficial. In the case of soil leaching and the consequent loss of plant food, especially nitrates, a crop is more valuable in the fall and early winter than earlier in the season, for in spring and summer the tree roots are in condition to take up much of the plant food as it becomes available; but from the time their leaves fall until the soil is frozen the plant food which would otherwise escape in the drainage water or be washed down beyond the reach of plants can be saved only by secondary crops, which grow until stopped by the severe weather of winter. Even in cases where the leaching of soils is not excessive a deep-rooting cover crop brings up plant food from the subsoil and leaves it near the surface to be used later by the trees.

Besides preventing in part the loss of fertilizing elements from the soil, cover crops may serve as a direct fertilizer. For this purpose the well-known ability of leguminous plants to take nitrogen from the air and store it, so that it can be used later by other plants, is made use of. The use of such crops in ordinary farm rotations is well known. That they may be equally useful in case of orchard fruits is shown by tests at the New Jersey Station. Crimson clover was sown in the peach orchard on sandy soil in the latter part of July and the crop was plowed under in the latter part of the following May. The cover crop retarded the growth of the trees somewhat in the spring, but after it

was plowed under they gained rapidly, and both wood growth and fruitage were more satisfactory than in the remainder of the orchard, which was fertilized with nitrate of soda. The use of leguminous crops, however, is not to be recommended in all cases. It often happens that soils become too rich in nitrogenous fertilizers, and the trees, therefore, grow too vigorously, do not mature their wood well, and are unfruitful. In such cases leguminous crops should not be used.

Cover crops may also improve the physical condition of the soil. In this connection the relation of humus to the water-holding capacity of the soil has been already noted. Humus is also beneficial in changing the character of very heavy soils, making them more porous and lessening their tendency to puddle in wet weather. Cover crops which live through the winter are of use in drying out heavy wet soils in spring so as to allow of cultivation.

Cover crops may also be advantageous in protecting the trees and fruit. The Delaware Station reports lessened injury to fruit blown from the tree where the soil was covered with a crop of crimson clover. In the extreme North cover crops are thought to be of advantage in preventing deep freezing and alternate freezing and thawing of the soil and the consequent injury to the roots of trees. At the Delaware Station ground covered with crimson clover is reported as unfrozen when the temperature of the air was 14° F. In some cases a cover may be injurious rather than beneficial to trees and fruit through the protection afforded to insects, mice, etc.

To secure the best results with a cover crop that lives over winter, it should be plowed under early in the spring while it is still succulent enough to decay rapidly. A crop plowed under late in the spring after it has become more or less woody will decay slowly, keep the soil too loose, and thereby serve to dry it out rather than retain its moisture. In many regions the crop may also do injury by the evaporation of moisture from its leaves if allowed to grow too late in spring.

The kind of crop that should be grown for winter cover must be determined by local conditions. In general the best crop is one that can be sown after tree growth stops, continues growth late in the fall, makes a close, thick cover, lives over winter, and furnishes considerable green manure. Nevertheless some crops which winterkill furnish considerable winter protection and serve fairly well the purpose of a green manure. Red clover and alfalfa, though good green-manure crops in general farming, are not suitable as a rule for growth in orchards, since they do not start well late in summer and require too much time to reach their full development. At the Canada Experimental Farms alfalfa and red clover proved inferior to mammoth clover. A mixture of alfalfa and mammoth clover, however, made a good cover; the mammoth clover covering the ground thickly below the taller and more slender alfalfa. Mammoth clover was considered the most satisfactory cover crop for Canada. It germinated promptly, soon took possession of the ground,

and began growth early in the following spring. At the New York State Station mammoth clover formed a dense covering and remained alive over winter, comparing favorably with winter vetch and winter rye. A mixture of the latter formed a perfect mat of vegetation and remained green over winter. At the New York Cornell Station the European vetch sown early in summer, though starting slowly, made a thick cover by the middle of September. It remained green and continued growing for some time after frost, the vines standing 2 feet high at the beginning of winter. On the approach of hard-freezing weather it fell, forming an even, carpetlike cover, and by spring the plants were decayed so they could easily be plowed under. The seed must not be sown too early for best results with summer cultivation, but the plant is, nevertheless, considered one of the best for New York. It is recommended to sow the seed the last of June or first of July or, if in very good soil, as late as the last of July. Soja beans and cowpeas have been successfuly grown in peach orchards in Connecticut. In Canada they are reported to have grown rapidly, but were killed by the first frost and did not make as good a cover as rye, buckwheat, or field peas. Cowpeas, and perhaps velvet beans[1] also, may prove valuable in the Southern States, but are not so well suited to the North. Both the New York stations report cowpeas as making a good growth, but the seed must not be sown too early to allow of the best cultivation. The plants are killed by the first frost, lose their leaves, and afford little winter protection. Field beans, while better than no cover, are open to the same objections as cowpeas. Field peas are often grown as a cover crop. At the New York Cornell Station field peas sown in the middle of August produced vines from 2 to 3 feet long and remained green after frost, making a good mulch. When sown as late as the middle of September they did not make a satisfactory cover. At the New York State Station Canada peas and buckwheat and blue peas and buckwheat gave satisfactory results, both mixtures making a good growth and the peas remaining green until winter. The growth of the Canada peas and buckwheat was so great as to interfere with the gathering of winter apples. Field peas are considered among the best crops for winter cover at the Nebraska Station, though most crops make a rather small growth in the dry falls of that region. Crimson clover[2] is considered an ideal cover crop wherever it withstands the winter, though it does not thrive on hard, poorly tilled soil as well as many other crops. It is reported by the New Jersey Station as being hardy throughout the State and considered much more economical than city manure as a nitrogenous fertilizer. It may be sown there from the middle of July to the middle of September. According to the Delaware Station, it is grown largely in the peach orchards of that State. It sends its roots to a depth of 4 feet even in hard soil, flourishes on poorer soil than red

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[1] U. S. Dept. Agr., Farmers' Bul. 78 (Expt. Sta. Work—V), pp. 12–14.

[2] U. S. Dept. Agr., Farmers' Bul. 69 (Expt. Sta. Work—III), pp. 8–10.

clover, and makes its growth during the fall, winter, and spring, growing when wheat and even rye seem dormant. In spring the sod is plowed in such a way as to leave many of the clover heads above the soil, to ripen and reseed the orchard. On poor soil cowpeas are sometimes grown during summer, and are followed by crimson clover sown in the pea vine in August. This practice is also recommended by the Virginia Station. Crimson clover has not proved entirely hardy at the Rhode Island, Michigan, New York State, and New Hampshire stations and at the Canada Experimental Farms, and was not satisfactory at the Nebraska Station on account of dry weather in the fall. In the locality of the New York Cornell Station crimson clover winterkills if sown too late. About the middle of July or first of August is recommended as the best time to sow it. If sown earlier, it matures and dies before winter. Failures with crimson clover are frequent, but no more so than with red or mammoth clover sown at the same time.

Where a nitrogenous fertilizer is not desired, rye is a good cover crop. It is also useful on very light sandy soils, and on very hard lumpy soils where other crops are not easily grown. A few years' growth of rye may improve such soils sufficiently to permit of the use of other crops. Turnips have been recommended for use on hard dry land, where other crops do not start readily. Sown late in July, they are said to make a good cover in the locality of New York Cornell Station. Rape[1] may also serve a useful purpose as a cover crop. At the New York State Station dwarf Essex rape made a very rank growth, sufficient to interfere with gathering winter fruit. It seemed to furnish hiding places for mice, which girdled the trees badly. This, however, may occasionally be true of any heavy cover. Corn sown thickly one and one-half to two months before frost makes a good winter cover, though killed quickly by cold weather. Buckwheat is also good for the same purpose if sown so as to reach its full height but not to produce seed before winter. Among other plants of more or less value as cover crops, oats, wheat, barley, millet, and spurry are sometimes recommended.

CULTIVATING v. CROPPING ORCHARDS.

Whether orchards shall be cropped or given clean cultivation, how cultivation shall be done, whether it shall be continued throughout the season, and similar problems depend very largely on local conditions of soil, climate, and the like. It is evident, therefore, that no definite rules can be given for the cultivation of orchards in all localities. The principles underlying successful culture, however, are the same everywhere, and therefore a knowledge of them will aid in deciding local questions.

Various experiment stations have conducted experiments to find out what methods give best results and why they do so. At the New York

[1] U. S. Dept. Agr., Farmers' Bul. 78 (Expt. Sta. Work—V), pp. 9-12.

Cornell Station it was found that the roots of trees only 5 or 6 years old have a greater spread than the tops. For instance, the roots of an apple tree in rich, cultivated soil extended 8 feet from the trunk, while the entire top was not over 8 feet across. Another apple tree in sod, with a top only 6 feet across, had roots 10 feet long. A pear tree in poor soil had roots 21 feet long, while its entire top measured only 7 feet across. The roots of an apple tree which had stood in sod since planting were just beneath the surface of the soil, while the roots of those in cultivated soil were nowhere less than 8 inches from the surface. These facts show that if orchards are to be cultivated at all they must be cultivated from the first, since otherwise the roots grow so near the surface as to be injured by plowing and cultivation. They also show that to get the full benefit of cultivation all the space between the trees must be cultivated.

At the Nebraska Station a study was made of the effect of cultivation on the growth of apple trees, the size of fruit, and the water content of the soil. A small orchard was divided into three parts, one of which was cultivated regularly and the other two left in grass and weeds, one of the latter being mowed and the other pastured by hogs. The report says: "Trees in cultivated ground suffered noticeably less from the drought and hot winds of summer than those in sod ground. The foliage was darker and more vigorous in appearance, and there was no yellowing and dropping of the leaves nor wilting during hot windy days, both of which occurred with uncultivated trees. Apples from cultivated land averaged nearly 14 per cent larger in weight than those from pasture land and over 17 per cent larger than those from mowed land." The average percentages of moisture in the first 20 inches of the soil in the different portions of the orchard in the latter part of October were: Mowed portion, 14; pasture portion, 14.7; portion cultivated until August 1, 17, and portion cultivated the entire season, 20.4. The next season the results were practically the same. The average percentages of moisture in the first 24 inches of soil in the last of August were: Pasture part, 14.6; mowed, 14.6; cultivated, 21.2. The differences in moisture were greater at a depth of 6 inches than the average differences given above, and were noticeable even at a depth of 20 inches. Observations on some grass land near the orchard showed that alfalfa only 2 years old took the moisture from the soil as completely as an old June grass sod. These facts show how very necessary cultivation is in a dry climate. That the same is true in dry seasons in moister climates is shown by observations at New York Cornell Station. Part of an orchard was given clean cultivation and another part was seeded to field peas in the spring, to be grown as a green manure crop. In the fall the percentages of moisture at a depth of 12 inches in the green manure plat were 8.7 to 9.6 and in the cultivated plat 11.3 to 12.8. Moreover, in the cultivated soil the moisture was distributed to within 2 inches of the surface of the soil, while in the

soil growing field peas the first few inches were exceedingly dry. The tree growth was less vigorous and the leaves lighter colored on the green manure plat than on the other. The leaves of peach trees on the cultivated plat were perfect, while on the green manure plat they turned yellow and fell. Similar differences were seen in the case of apricots, pears, and plums.

The California Station has recently reported an instance of the beneficial effect of cultivation on the growth and fruitfulness of orchards. Apricots grown in adjacent fields under exactly the same conditions, except for cultivation, showed great difference in behavior (fig. 3). The soil of the region in which the orchards are located has a rather loose texture. One orchard was cultivated several inches deep and the other was uncultivated. During one season the trees in the cultivated field made a wood growth of over 3 feet, while those in the

FIG. 3.—Cultivated (*A*) and uncultivated (*B*) apricot trees in a dry season.

uncultivated field made a growth of not over 3 inches. There was also a great difference in the fruit. The average percentage of moisture in the first 6 feet of soil was 6.3 in the cultivated orchard and 4.2 in the other one. A recent bulletin of the Illinois Station reports marked benefit from clean cultivation of an orchard. In 1890 three rows each of Ben Davis and Grimes Golden apples were planted, the trees being set 15 feet apart each way. These were divided into 4 plats, the first being given clean cultivation and the second, third, and fourth being cropped with oats, clover, and blue grass, respectively (fig. 4). The same treatment was continued each year after planting. The trees grown on the grass plats were decidedly inferior to those grown on the cultivated plat as regards height, diameter of trunk, vigor, and abundance of foliage, etc. For instance, in the case of the Ben Davis trees the diameter of the trunks 1 foot above the surface of the soil was about twice as great in the case of the cultivated plat as in case of that in grass. Similarly the height of the trees in the two plats averaged 18¾

and 11 feet, and the diameter of the tops 15⅓ and 8¼ feet, respectively. In the growth and vigor of trees, the clover plat ranked next after the cultivated plats, and the oats plat ranked between the clover and blue grass plat. An examination of the root systems of trees on the different plats also showed the superiority of clean cultivation, especially over cropping with oats and grass. In the cultivated plat the root system was compact and reached a considerable depth, while in the oats and grass plats the roots grew shallow and ranged widely from the tree. There was also a difference in the moisture content of the soil in the different plats. In the latter part of October, 1897, the average percentages of moisture in the first 27 inches of soil of the various plats were for the cultivated and corn plats 12, for the clover plat 10, and for the oats and grass plats 8. The effect of the different treatments is seen in figure 4 which shows a typical tree from each of the 4 plats.

FIG. 4.—Effect of different systems of culture on the growth of apple trees: *A*, clean cultivation; *B*, cropped with oats; *C*, cropped with clover; *D*, cropped with blue grass.

The injury caused by growing grass in young orchards is shown very emphatically by an experiment conducted at the Utah Station. Parts of an orchard were seeded to alfalfa, timothy, clover, and a mixture of timothy and clover soon after the trees were set, and other parts were cultivated, all being irrigated alike. Over half of the trees in the grass plats died and were reset twice, while the cultivated trees lived and grew well. It is not to be expected that growing grass in young orchards is always as injurious as it proved to be at the Utah Station, yet the reported experiences of fruit growers and experimenters everywhere show the importance of carefully cultivating young orchards. Even in a climate as moist as that of England grass proves very detrimental to young trees. At the Woburn Experimental Fruit Farm a mixture of grass recommended for orchards was sown around young apple trees and other trees were cultivated, the two lots being treated alike in other respects. The second year after sowing the grass the trees in the grass plat made 35 to 41 per cent less leaf growth and

74 to 87 per cent less wood growth than trees in the cultivated plat. In the case of dwarf trees bearing fruit for the first time the grass reduced the yield 71 per cent in weight and 82 per cent in value. Grass sod was much more injurious than weeds which lived but one year.

From the experiments referred to above it would appear that the growth of grass, weeds, and even such plants as field peas, through the entire season without cultivation, especially in young orchards, is to be regarded as an injurious practice. The growth of grass, weeds, and cereal crops makes impossible cultivation, which would not only check evaporation of water from the soil, but would also prepare the soil to hold more of the rainfall, make plant food available to the trees, send the tree roots down to the subsoil, and the like. Aside from preventing cultivation, the crops noted evaporate a great amount of water through their leaves, and, if removed from the orchard, rob it of fertility.

Notwithstanding all this, it must not be inferred that clean cultivation is best in all cases. If the trees are set in fertile soil there is usually no injurious effect from growing a secondary crop between the rows while the trees are young and their roots do not occupy the entire soil, but the secondary crop should always be one that requires careful cultivation and does not evaporate moisture excessively, such as beans, peas, potatoes, cabbage, squashes, melons, and the like. The crops noted, and other similar ones, if not planted too close to the trees, do not hinder cultivation, and they evaporate comparatively little moisture. As an example of this, it has been shown at the Nebraska Station that in midsummer the moisture content of the soil of well-cultivated plats of cabbage, beans, peas, and potatoes was but little less than that of cultivated fields in which no crop was growing. Such plants as squashes and melons may hinder cultivation late in the season, but that is usually not a disadvantage, as shown later. As the trees grow the crops should be planted farther from them until the tree roots occupy all the ground, when it is usually best to discontinue growing secondary crops. Orchards with trees set 20 feet apart should rarely be cropped more than three years, but apple orchards can often be cropped for seven or eight years. When the trees begin to bear it is usually time to stop cropping the orchards.

Aside from the growth of secondary crops in orchards, there are other cases where clean cultivation is not best. It often happens that in very rich soil or in very moist localities fruit trees grow vigorously, but do not fruit well. It is then necessary to do something to check the growth and induce fruitfulness. This may often be accomplished by seeding the orchard to grass. How long grass should be allowed to remain can be determined only by the growth, fruitfulness, and appearance of the trees. If the growth becomes very weak and the leaves are light-colored it is an indication that cultivation should be resumed. Indeed, it should have been resumed before these conditions appeared.

Another case in which clean cultivation is not best is where orchards in very light soils are subject to the washing and leaching of heavy rains. In such cases it may be advantageous to grow a secondary crop in summer, to hold the soil and prevent the washing out of food materials. This binding of orchard soils by means of secondary crops may well be combined with the improvement of the soil by green manuring. In the majority of cases, however, this treatment will be found unnecessary. But even where summer treatment is not necessary it is often well to grow some crop to protect the soil and trees during winter and to improve the soil. In this case, then, clean cultivation during the first part of the season may be followed later by the use of some cover crop.

APPLICATION OF WATER PRESSURE TO TRANSPLANTED TREES.

The Wisconsin Station has recently reported experiments in applying slight water pressure to the roots of newly transplanted trees as a means of promoting the starting of their buds, thereby preventing failure in transplanting. A vessel containing a small quantity of water is supported at a height equal to or slightly exceeding that of the tree and connected by a tube with a root of the tree, so that the pressure exerted by the column of water in the tube is communicated to the water within the tree. In the tests made at the station a flask of water was supported on a stake driven in the ground near the tree and a rubber tube used to connect the flask with the root. A simpler and more substantial form of apparatus is recommended for general use (fig. 5). A cup with a small opening in the bottom is soldered to one end of a small gas pipe and a cap screwed on to close the other end. Near the closed end the pipe has a T connected with a brass nipple to which a short rubber tube is attached.

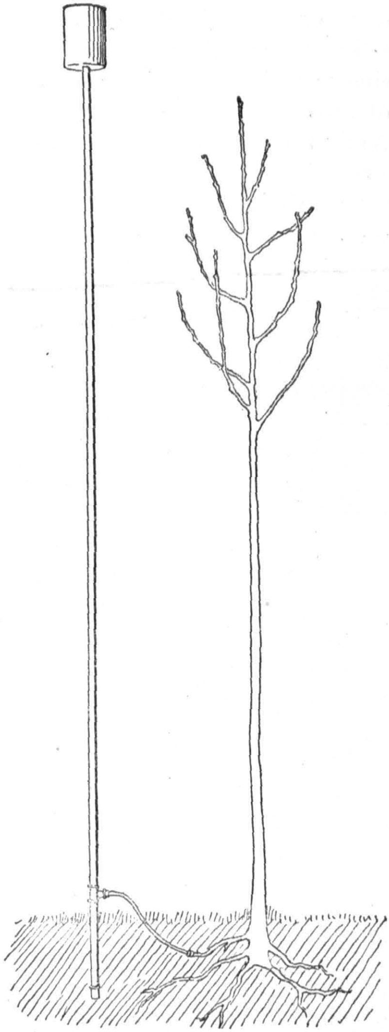

FIG. 5.—Apparatus for applying water pressure to transplanted trees.

The soil is removed from the end of a root and the closed end of the gas pipe shoved into the ground near enough to the tree to allow the rubber tube to slip over the end of the root. The end of the rubber tube is then closed with a cork and the apparatus filled with water, when the cork is removed and the end of the tube slipped over the end of the root and tied with a cord.

The effect of the water pressure was often very quickly noticed, sometimes within forty-eight hours. Pressure was applied in the latter part of May, 1896, to a small purple beech tree which had been planted in April but had shown no indications of opening its buds. Six days

FIG. 6.—Effect of artificial root pressure on the opening of buds.

later the buds had opened sufficiently to show the leaves plainly. In the middle of May, 1896, water pressure was applied to a tree of the "City" plum which had been planted nearly a month previous. Several leaf buds had opened but had been dried up by hot, dry weather. A week after the pressure was applied many buds which had not opened before began to swell, and in about another week the leaves were pushing out vigorously. In the spring of 1897, twenty Whitney crab-apple trees were planted in rather poor, dry soil. The roots of these trees had been exposed for a time during the winter to the warm, dry atmosphere of the garden house, having been used by students in lessons in

transplanting, and had then been kept in damp soil in a cellar. During the four days preceding planting the roots were exposed to the air but protected from the rain and snow. The trees were planted in the latter part of April without special care, and water pressure was applied to a root of each alternate tree. The weather was clear, with occasional showers. In one week after planting, the buds on the trees supplied with water pressure began to open, and in two weeks every tree thus treated was starting well. During the next two weeks, with dry, clear weather, the treated trees continued with one exception to expand their leaves. By this time the buds on one of the untreated trees began to start, but those on the other untreated trees showed no sign of starting. (See fig. 6.) Later the ground was well irrigated and mulched. All the trees ultimately grew except two, both failures being in the untreated lot, and by fall little difference could be seen between the trees of the treated lot and the live ones of the untreated lot, showing that the advantage of the treatment is only in starting growth.

The apparatus has not thus far been tested on trees more than four years old nor on evergreens. Whether it will be found advantageous to use this treatment in transplanting large trees can not be said at present. Whether it is found economical in ordinary work or not, it will undoubtedly prove a very valuable means of preventing failure in transplanting trees under unfavorable conditions, especially in the case of rare or otherwise specially valuable trees.

In regard to the practical value of the treatment the bulletin says:

> Trees of which the bark is shriveled and the buds blackened by undue drying, or of which the roots have been killed by severe freezing in a dry soil, can not be saved by this treatment; but trees of which the bark and buds are plump, that are unable to expand their leaves even when the soil about their roots is moist, may generally be assisted to do so by the apparatus here described. The treatment will probably have especial value for trees that it is desired to plant without severe cutting back of the top.

THE FECUNDITY OF SWINE.

The impression is prevalent among farmers that pure-bred swine are unprofitable for breeding purposes, as it is thought that as purity of breed increases fecundity decreases. The question of the fecundity of improved breeds of swine was investigated recently by the Indiana Station. The number of pigs farrowed and raised in the first and the last 200 litters recorded in the registers of Berkshire, Poland-China, and Chester White pigs were compiled. In comparing the litters, 100 litters were selected in which the sows were recorded, and 100 in which the boars were recorded. The dates of farrowing of the first 200 litters varied through a number of years. The last 200 litters were almost all farrowed in 1896. The popular opinion was not confirmed by this investigation.

While there seems to be a reduction in the number of very large litters, the total number farrowed is about the same as shown by the first records.

It is not the intent to compare breeds, but to compare the earliest and latest records of litters, to determine whether there has been a real gain or loss in the fecundity of the breed.

The number of boars and sows raised was as follows: Berkshire, 400 litters, 2,866 pigs, 1,498 boars, 1,368 sows; Poland-China, 1,000 litters, 6,542 pigs, 3,228 boars, 3,314 sows; Chester White, 600 litters, 4,555 pigs, 2,236 boars, 2,319 sows. In a total of 3,693 pigs farrowed, and all raised, there were 1,786 boars and 1,907 sows.

FOOD VALUE OF HENS' EGGS.

Eggs are generally regarded as a valuable and nutritious food. According to a large number of American analyses, an egg on an average weighs 2 ounces and has the following percentage composition: Shell, 10.5; water, 66; protein, 13.1; fat, 9.3; and ash, 0.9. A side of beef contains on an average about the same percentage of protein, but a larger percentage of fat. Eggs belong to the nitrogenous group of foods, and would naturally and quite properly be combined in the diet with materials supplying carbohydrates (sugar and starch), such as cereals, potatoes, etc.

The California Station has recently reported an extended study of the physical properties and chemical composition of eggs, the chief object being to determine whether there was any basis of fact for the popular opinion that eggs with brown shell have a higher food value than those with white shell. The brown-shelled eggs were from Partridge Cochins, Dark Brahmas, Black Langshans, Wyandottes, and Barred Plymouth Rocks, and the white-shelled eggs from Brown Leghorns, Buff Leghorns, White Minorcas, and Black Minorcas. The size, weight, specific gravity, and the ratio to total weight of the shell, yolk, and white are shown in the following table:

Comparison of brown-shelled and white-shelled eggs.

	Weight.	Length	Width.	Specific gravity.	Number of eggs to pound.	Shell.	Edible portion.		
							Total.	Yolk.	White.
	Grams.	*Inches.*	*Inches.*			*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Brown-shelled eggs (average of 6 breeds)	59.4	2.27	1.69	1.082	7.67	10.70	89.30	31.76	57.54
White shelled eggs (average of 4 breeds)	62.9	2.27	1.76	1.058	7.83	10.92	89.08	33.18	59.90
Average of above ..	61.2	2.27	1.72	1.070	7.50	10.81	89.19	32.47	56.72

The composition of the eggs of the different breeds is recorded in detail. The averages are given in the following table:

Analyses of brown-shelled and white-shelled eggs.

	Water.	Protein.	Fat.	Ash.	Shell.	Total.
Brown-shelled eggs:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Yolk	49.59	15.58	33.52	1.04	....	99.73
White	86.60	11.99	.21	.54	....	99.34
Entire egg	65.57	11.84	10.77	.64	10.70	99.52
White-shelled eggs:						
Yolk	49.81	15.49	33.34	1.05	....	99.69
White	86.37	12.14	.35	.56	....	99.42
Entire egg	64.79	11.92	11.22	.67	10.92	99.52

It has been said by some that the brown eggs are richer than the white ones. This statement is not borne out by a chemical analysis, and the physical examination proves that the main points of superiority, though extremely slight, are possessed by the white eggs. The minute differences that are found between the two groups are exceeded by variation between the varieties within the same group.

We can therefore state as a conclusion, both from a chemical and a physical point of view, that there are practically no differences, so far as the food value is concerned, between the white-shelled and brown-shelled eggs.

The Michigan Station has recently reported a study of the chemical composition of eggs from different breeds of hens. These were Brown Leghorns, Barred Plymouth Rocks, Buff Cochin, Silver Gray Dorkings, White Wyandottes, and Partridge Cochin. The variation in composition of the eggs of the different breeds was too small to be regarded as of any practical value. It would undoubtedly be no greater than the variations between different samples of eggs from the same breed. The effect of the character of rations on the composition of eggs was also tested with two lots of Barred Plymouth Rocks, Wyandottes, and Brown Leghorn hens. The test covered six weeks. Lot 1 was fed a mixture of 1 part of meat scraps, 8 parts of wheat, and 1 part of oil meal. Lot 2 was fed with a mixture of 7 parts of corn, 1 part of tallow, and 2 parts of rice meal. Both lots were given lettuce and oyster shells in abundance. No marked variation in the composition of the eggs due to different rations was observed, but the test is not regarded as conclusive, since it was of short duration.

The value of any food is determined not alone by its composition, but also by its digestibility. It is evident that if two foods have the same composition, but owing to physical properties or other cause the first gives up twice as much material to the body in its passage through the stomach as the second it is much more valuable. In connection with other work the digestibility of eggs was studied at the Minnesota Station. Five experiments were made by means of a pepsin solution to determine the digestibility of eggs cooked under different conditions. Eggs were cooked for 3 minutes at 212° F., giving a "soft-boiled" egg, and for 5 minutes and 20 minutes at the same temperature. An egg boiled 3 minutes and digested for 5 hours in pepsin solution, compared

with one boiled 20 minutes and treated in the same way, showed 8.3 per cent undigested protein in the former, against 4.1 per cent undigested protein in the latter. Under similar treatment the egg boiled 5 minutes gave 3.9 per cent undigested protein.

Another trial was then made, in which the eggs were cooked for periods of 5 and 10 minutes in water at 180° F. In both of these cases the protein was entirely digested in 5 hours.

These results would indicate that while the method of cooking has some effect upon the rate of digestibility, it does not materially affect the total digestibility. The results agree quite closely with those reported some years ago by Rubner, a German investigator, who found that 97.1 of the protein of hard-boiled eggs was digested.

At the Minnesota Station a digestion experiment was also made with a healthy man, in which a very considerable portion of the nitrogenous material and fat of the ration was furnished by eggs, the other foods eaten being potatoes, milk, and cream. About 90 per cent of the total nitrogenous material and 90 per cent of the fat consumed were digested. In experiments at the University of Tennessee with healthy men on a diet of bread, milk, and eggs from 90 to 95 per cent each of the protein and fat were digested. The conclusion therefore seems warranted that, as shown by composition and digestibility, eggs possess the high nutritive properties which are popularly assigned to them.

For a number of years this Department has been carrying on food investigations in different parts of the country. One of the objects was to learn the kinds and amounts of food consumed by persons engaged in various occupations and the relative cost of such foods. Compared with other foods at the usual prices, eggs at 12 cents per dozen were found to be a cheap source of nutrients; at 16 cents per dozen, they were fairly expensive; and at 25 cents per dozen and over they were very expensive.

THE SWEET POTATO AS A STARCH PRODUCER.

By far the larger part of the starch of commerce is at present manufactured from corn, potatoes, and rice. Potatoes are largely used on the continent of Europe, rice principally in England, but corn almost exclusively in America. In selecting a starch-producing plant two things must be taken into consideration, (1) the amount of starch yielded per acre and (2) the cost of separating the starch. The general use in the United States of corn as a starch producer is undoubtedly due to its widespread culture, its high content of starch, and the ease and cheapness with which the latter is produced. While it is not likely that any of our common crops can successfully compete with corn as a starch producer under the ordinary conditions at present prevailing in the United States, there may be special conditions under which the utilization of other starch-producing plants may prove profitable.

The sweet potato has frequently been suggested as a possible profit-

able starch producer, but little has actually been done to determine its value for this purpose. The South Carolina Station has recently made some studies on the sweet potato which have an important bearing on this point. Analyses of samples of potatoes from different sources showed an average starch content of over 20 per cent, running as high as 26 per cent in some cases. In two samples the starch was separated mechanically. In the first, which chemical analysis showed to contain 22.82 per cent of starch, 20.61 per cent was obtained by mechanical means; the second, containing 21.74 per cent, yielded 19.96 per cent by mechanical separation. The material thus separated was quite pure, containing 96 per cent of pure starch.

Assuming a yield of 20 bushels, or 1,200 pounds, of wheat per acre; 35 bushels, or 1,960 pounds, of corn, and 200 bushels, or 1,200 pounds, of sweet potatoes, the yield of starch is estimated to be: From wheat, 684 pounds; corn, 1,283, and sweet potatoes, 2,640. It is thus seen that the amount of starch yielded per acre by sweet potatoes is largely in excess of that yielded by cereals. The sweet potato also appears to have some advantage in this respect over the white potato, which is so largely used in Europe.

Besides the question of the yield of starch, however, there are other things to be taken into consideration, viz, the cost of production of the sweet potato, the changes that may take place in storage, the cost of manufacturing the starch, and, finally, the properties of the starch itself.

It is claimed that a given amount of starch is produced at much less cost in sweet potatoes than in cereals and white potatoes. A fact which must be taken into account, however, in considering the value of the sweet potato for starch manufacture is that there is a considerable change of starch into sugar in storage.

The Texas Station found that "a sweet potato containing 2.77 per cent of total sugar originally, when kept for a month and a half, increased its total sugar content to 11.63 per cent, and in four months still further increased it to 13.8 per cent." The extent of the loss from this source, of course, depends largely upon the length and manner of storage.

The questions involving the manufacture of the starch on a large scale and the fitness of the product for sizing and other purposes can be best determined by a factory test. It is believed that the results already obtained are sufficiently promising to justify those who are interested in this subject in trying to have a factory test made. * * *

While in communities near large markets the sweet potato always brings a good price, yet in districts removed from market facilities it hardly pays to ship them, and it is in the latter districts that starch factories could no doubt be placed with advantage.

An important factor to be taken into consideration in this connection is the character of the refuse left after extracting the starch. Corn contains considerable amounts of protein, and when used for the manufacture of starch furnishes by-products rich in this constituent, and

therefore very valuable feeding stuffs. Gluten meal and feed are examples of these by-products. Sweet potatoes, on the other hand, contain much less protein, and would therefore furnish a much less valuable by-product.

THE TOAD AS A FRIEND OF THE FARMER.

Great and beneficent results are often accomplished through very humble agencies. Darwin has established the claim of the earthworm to the gratitude of the tiller of the soil, and modern science is revealing thousands of hitherto unseen and unknown agencies working in the interests of man. Science now comes forward to establish what a few have long maintained, viz, that the ugly and despised toad is a faithful and efficient servant of the farmer.

From the earliest times, as a bulletin of the Massachusetts Hatch Station states, the toad has been associated in the popular mind with a host of "vague and ludicrous fancies as to its venomous qualities, its medicinal virtues, or, most commonly, the hidden toadstone of priceless value." To these venerable creations of the imagination have been added others equally absurd, such as "that touching toads will produce warts on the hands; that killing toads will produce bloody milk in cows; that a toad's breath will cause convulsions in children; that a toad in a newly dug well will insure a good and unfailing supply of water, or in a new-made cellar will bring prosperity to the household, etc." This station has made an investigation of the habits, food, and economic value of the American toad which dispels these fallacious ideas, and at the same time establishes the claim of the little animal to our consideration and appreciation.

In New England the toad usually emerges from its hibernating quarters during the month of April. Cold weather retards its movements, but on warm days at this season the toads may be found on their way to the ponds and stagnant pools, where a little later the characteristic shrill cry may be heard throughout the day and evening. Mating is commenced as soon as the water is reached, or even before, and in a few days the long slimy "ropes" of eggs deposited by the female may be found in the pools. The eggs are nearly black in color and rapidly increase in size. In two weeks the young tadpoles are clearly outlined, and in three or four weeks the eggs hatch. The vegetable detritus of the pond bottoms and the slime and algæ attached to sticks, plants, etc., seem to be the common food of the tadpole. Warm weather favors the growth of the tadpoles, and usually by July 1 to 15 the young toads are fully developed, leave the water and spread over the fields. At this stage they are exceedingly sensitive to heat, and secrete themselves under leaves, rubbish, stones, etc., during the day; but let a vigorous shower descend and the transformation is magical. The walks, roads, and gardens at once become peopled with myriads of these thirsty, leaping creatures, and their sudden appearance has led to the popular belief that they "rain down." It is fortunate for them that when young they are unable to endure solar heat, otherwise large numbers would probably be destroyed by the birds which are active during the day; doubtless many are killed by the predaceous birds and mammals which prowl by night.

Many conflicting statements have been made regarding the longevity of the toad, but "there can be but little doubt that toads live to a considerably greater age than is supposed, and we may hazard the opinion that many of them reach an age of at least 10 or 15 years."

Experiments have been made which "show that it is possible for the toad to exist for a limited time without food, but throw a shadow of improbability upon the stories of those found in rocks, trees, etc."

When suddenly disturbed or roughly handled the toad ejects a colorless fluid from the anus and a milky liquid from the skin. This habit is probably the basis for the belief that the toad is venomous. The secretion of the skin glands is harmless when applied to the hands, but it evidently possesses acrid properties, since when toads are bitten by dogs or cats the latter usually have a copious flow of saliva, show signs of discomfort, and in some cases coming under the observation of the writer have manifested considerable distress. That this fluid is not objectionable to all animals is apparent from the fact that many hawks, owls, etc., include the toad in their bill of fare.

The toad sheds its skin four or five times each year. There is a popular notion that the toad swallows the molted skin, but this was not observed in this study.

On the approach of cool weather, sometimes as early as the 1st of September, toads begin to seek winter quarters. These they find in cellars, under buildings, rocks, leaves, or rubbish, and in places where the action of frost will not be felt. Cold benumbs them but does not kill.

The toad can not endure high temperatures. Properly speaking, it is a nocturnal animal, and ventures out during the day only when tempted by an abundance of food in its immediate vicinity or when the air is full of moisture. It eats only living and moving insects, centipedes, etc.

The toad's tongue, its only organ for seizing food, is soft, extensile, attached in front but free behind, and is covered with a glutinous substance which adheres firmly to the food seized. So rapid is the motion of this weapon that a careful watch is necessary in order to see the animal feed. * * *

At night, soon after sundown, or even before on cool evenings, the toad emerges from its shelter and slowly hops about in search of food. Something of a regular beat is covered by these animals, whose sense of locality is quite strong. In the country this includes forays along roadsides, into gardens and cultivated fields, and wherever insect food is abundant and grass or other thick herbage does not prevent locomotion. In cities and suburban villages the lawns, walks, and particularly the spots beneath electric lamps, are favorite hunting grounds.

The toad as a rule feeds continuously throughout the night, consuming in twenty-four hours an amount of food equal in bulk to about four times the stomach capacity.

A careful examination of the contents of the stomachs of a large number of toads showed that 98 per cent of its food was animal matter—worms, insects, etc. "Eleven per cent of the toad's food is composed of insects and spiders beneficial or indirectly helpful to man; 80 per cent of insects and other animals directly injurious to cultivated crops or in other ways obnoxious to man." It is estimated that a single toad

destroys in a year insects which, if they had lived, might have damaged crops to the extent of about $20.

To all agriculturists the toad renders conspicuous service, but gardeners and greenhouse owners may make this animal of especial value. Every gardener should aim to keep a colony of toads among his growing crops and the practice of collecting and transferring them to the gardens is a commendable one. While the sense of locality is strong in this batrachian and it will often return over considerable distances to its original haunts, yet it may be induced to remain in new quarters if there is a sufficient food supply. * * *

The crow and various species of hawks and owls are the chief natural enemies of the toad, but as a common enemy of the toad the ubiquitous small boy plays a prominent part. Seventeen toads dead and more or less mutilated were once observed at Malden, Mass., lying on the shores of a small pool. This was the result of a couple of hours' amusement on the part of two juveniles.

This is not an extreme case. Such cruel and senseless persecution is only of too common occurrence. The loud cry of the toad at spawning time readily betrays its presence, and small boys, and sometimes those of larger growth, gravitate toward the pools as naturally as do the toads themselves. There have been excellent laws enacted to protect our insectivorous birds. Why should there not be as stringent legislation against the destruction of toads? If merit of service rendered to man be the standard by which legislation is determined, the toad presents a record which will compare favorably with that of any insectivorous bird. Public sentiment in a matter like this, however, exerts a stronger influence than legislation, and when the services of this animal are appreciated and the toad receives in our public schools recognition similar to that given to the birds, then we may expect to see a lessening of the wanton destruction of this humble servant of man.

EXPLANATION OF TERMS.

TERMS USED IN DISCUSSING FERTILIZERS.

Complete fertilizer is one which contains the three essential fertilizing constituents, i. e., nitrogen, phosphoric acid, and potash.

Nitrogen exists in fertilizers in three distinct forms, viz, as organic matter, as ammonia, and as nitrates. It is the most expensive fertilizing ingredient.

Organic nitrogen is nitrogen in combination with other elements either as vegetable or animal matter. The more valuable sources are dried blood, dried meat, tankage, dried fish, and cotton-seed meal.

Ammonia is a compound of nitrogen more readily available to plants than organic nitrogen. The most common form is sulphate of ammonia, or ammonium sulphate. It is one of the first products that results from the decay of vegetable or animal substances.

Nitrates furnish the most readily available forms of nitrogen. The most common are nitrate of soda and nitrate of potash (saltpeter).

Phosphoric acid, one of the essential fertilizing ingredients, is derived from materials called phosphates. It does not exist alone, but in combination, most commonly as phosphate of lime in the form of bones, rock phosphate, and phosphatic slag. Phosphoric acid occurs in fertilizers in three forms—soluble, reverted, and insoluble phosphoric acid.

Potash, as a constituent of fertilizers, exists in a number of forms, but chiefly as chlorid or muriate and as sulphate. All forms are freely soluble in water and are believed to be nearly, if not quite, equally available, but it has been found that the chlorids may injuriously affect the quality of tobacco, potatoes, and certain other crops. The chief sources of potash are the potash salts from Stassfurt, Germany—kainit, sylvinit, muriate of potash, sulphate of soda, and sulphate of potash and magnesia. Wood ashes and cotton-hull ashes are also sources of potash.

TERMS USED IN DISCUSSING FOODS AND FEEDING STUFFS.

Water is contained in all foods and feeding stuffs The amount varies from 8 to 15 pounds per 100 pounds of such dry materials as hay, straw, or grain to 80 pounds in silage and 90 pounds in some roots.

Dry matter is the portion remaining after removing or excluding the water.

Ash is what is left when the combustible part of a feeding stuff is burned away. It consists chiefly of lime, magnesia, potash, soda, iron, chlorin, and carbonic, sulphuric, and phosphoric acids, and is used largely in making bones. Part of the ash constituents of the food is stored up in the animal's body; the rest is voided in the urine and manure.

Protein (nitrogenous matter) is the name of a group of substances containing nitrogen. Protein furnishes the materials for the lean flesh, blood, skin, muscles, tendons, nerves, hair, horns, wool, casein of milk, albumen of eggs, etc., and is one of the most important constituents of feeding stuffs.

Gluten is the name given to one of the most important of the nitrogenous substances classed together under the general term "protein." "Wheat gum," obtained by carefully chewing wheat, is a familiar example. It is the gluten of flour that gives consistency to dough.

Carbohydrates.—The nitrogen-free extract and fiber are often classed together under the name of carbohydrates. The carbohydrates form the largest part of all vegetable foods. They are either stored up as fat or burned in the body to produce heat and energy. The most common and important carbohydrates are sugar and starch.

Fiber, sometimes called crude cellulose, is the framework of plants, and is, as a rule, the most indigestible constituent of feeding stuffs. The coarse fodders, such as hay and straw, contain a much larger proportion of fiber than the grains, oil cakes, etc.

Nitrogen-free extract includes starch, sugar, gums, and the like, and forms an important part of all feeding stuffs, but especially of most grains.

Fat, or the materials dissolved from a feeding stuff by ether, is a substance of mixed character, and may include, besides real fats, wax, the green coloring matter of plants, etc. The fat of food is either stored up in the body as fat or burned to furnish heat and energy.

MISCELLANEOUS TERMS.

Alkali soils.—Soils found in arid or semiarid regions, which contain an unusual amount of soluble mineral salts (alkali), which effloresce or bloom out in the form of a white powder or crust in dry weather following rains or irrigation. Two distinct classes of alkali are known: White alkali, composed largely of sulphate of soda and common salt, which is comparatively harmless; and black alkali, composed largely of carbonate of soda, which is highly corrosive and destructive to vegetation.

Humus is the name applied to the partially decomposed organic (animal and vegetable) matter of the soil. It is the principal source of nitrogen in the soil.

Leguminous plant is a plant of the botanical order Leguminosæ, the principal representatives of which are clover, peas, beans, etc.

Specific gravity of solid substances is the ratio of the weight of a given bulk of the body to that of an equal bulk of water; or, stated in another way, the ratio of the weight of the substance in air to its weight in water.

Pepsin.—A substance (ferment) found in the juices of the stomach, which aids in the digestion of food. It is prepared in a comparatively pure state on a commercial scale from the lining membrane of pigs' stomachs.

FARMERS' BULLETINS.

These bulletins are sent free of charge to any address upon application to the Secretary of Agriculture, Washington, D. C. Only the following are available for distribution:

No. 15. Some Destructive Potato Diseases: What They Are and How to Prevent Them. No. 16. Leguminous Plants for Green Manuring and for Feeding. No. 18. Forage Plants for the South. No. 19. Important Insecticides: Directions for their Preparation and Use. No. 21. Barnyard Manure. No. 22. Feeding Farm Animals. No. 23. Foods: Nutritive Value and Cost. No. 24. Hog Cholera and Swine Plague. No. 25. Peanuts: Culture and Uses. No. 26. Sweet Potatoes: Culture and Uses. No. 27. Flax for Seed and Fiber. No. 28. Weeds; and How to Kill Them. No. 29. Souring of Milk and Other Changes in Milk Products. No. 30. Grape Diseases on the Pacific Coast. No. 31. Alfalfa, or Lucern. No. 32. Silos and Silage. No. 33. Peach Growing for Market. No. 34. Meats: Composition and Cooking. No. 35. Potato Culture. No. 36. Cotton Seed and Its Products. No. 37. Kafir Corn: Characteristics, Culture, and Uses. No. 38. Spraying for Fruit Diseases. No. 39. Onion Culture. No. 40. Farm Drainage. No. 41. Fowls: Care and Feeding. No. 42. Facts About Milk. No. 43. Sewage Disposal on the Farm. No. 44. Commercial Fertilizers. No. 45. Some Insects Injurious to Stored Grain. No. 46. Irrigation in Humid Climates. No. 47. Insects Affecting the Cotton Plant. No. 48. The Manuring of Cotton. No. 49. Sheep Feeding. No. 50. Sorghum as a Forage Crop. No. 51. Standard Varieties of Chickens. No. 52. The Sugar Beet. No. 53. How to Grow Mushrooms. No. 54. Some Common Birds in Their Relation to Agriculture. No. 55. The Dairy Herd: Its Formation and Management. No. 56. Experiment Station Work—I. No. 57. Butter Making on the Farm. No. 58. The Soy Bean as a Forage Crop. No. 59. Bee Keeping. No. 60. Methods of Curing Tobacco. No. 61. Asparagus Culture. No. 62. Marketing Farm Produce. No. 63. Care of Milk on the Farm. No. 64. Ducks and Geese. No. 65. Experiment Station Work—II. No. 66. Meadows and Pastures. No. 67. Forestry for Farmers. No. 68. The Black Rot of the Cabbage. No. 69. Experiment Station Work—III. No. 70. The Principal Insect Enemies of the Grape. No. 71. Some Essentials of Beef Production. No. 72. Cattle Ranges of the Southwest. No. 73. Experiment Station Work—IV. No. 74. Milk as Food. No. 75. The Grain Smuts. No. 76. Tomato Growing. No. 77. The Liming of Soils. No. 78. Experiment Station Work—V. No. 79. Experiment Station Work—VI. No. 80. The Peach Twig-borer—an Important Enemy of Stone Fruits. No. 81. Corn Culture in the South. No. 82. The Culture of Tobacco. No. 83. Tobacco Soils. No. 84. Experiment Station Work—VII. No. 85. Fish as Food. No. 86. Thirty Poisonous Plants. No. 87. Experiment Station Work—VIII. No. 88. Alkali Lands. No. 89. Cowpeas.

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